

LISTINGS OF THE CLAIMS

In the claims:

1. (Original) A CPP giant magnetoresistive head comprising:
lower and upper shield layers with a predetermined shield distance therebetween; and
a giant magnetoresistive element comprising a pinned magnetic layer, a free magnetic layer, and a nonmagnetic layer interposed between the pinned magnetic layer and the free magnetic layer, which are disposed between the upper and lower shield layers, a current flowing perpendicularly to the film plane of the giant magnetoresistive element;
wherein an antiferromagnetic layer is provided in the rear of the giant magnetoresistive element in a height direction, for pinning the magnetization direction of the pinned magnetic layer in the height direction.
2. (Withdrawn) The CPP giant magnetoresistive head according to claim 1, wherein the antiferromagnetic layer is in contact with the rear end surface of the pinned magnetic layer in the height direction to produce an exchange coupling magnetic field at the interface with the rear end surface in the height direction, so that the magnetization direction of the pinned magnetic layer is pinned by the exchange coupling magnetic field.
3. (Original) The CPP giant magnetoresistive head according to claim 1;
wherein at least a portion of the pinned magnetic layer extends to the rear of the magnetoresistive element in the height direction; and
the antiferromagnetic layer is in contact with the upper surface or the lower surface of the rear portion of the pinned magnetic layer extending in the height direction to produce an exchange coupling magnetic field at the interface with the upper or lower surface, so that the magnetization direction of the pinned magnetic

layer is pinned by the exchange coupling magnetic field.

4. (Original) The CPP giant magnetoresistive head according to claim 1, wherein the length of the pinned magnetic layer in the height direction is larger than that in the track width direction.

5. (Original) The CPP giant magnetoresistive head according to claim 1, wherein the pinned magnetic layer comprises a magnetic material having a positive magnetostriction constant and is exposed at a surface facing a recording medium.

6. (Original) The CPP giant magnetoresistive head according to claim 3; wherein the pinned magnetic layer is formed in a laminated ferrimagnetic structure comprising first and second pinned magnetic layers which are laminated with a nonmagnetic intermediate layer provided therebetween;

the nonmagnetic layer and the free magnetic layer are formed on the second pinned magnetic layer;

each of the first pinned magnetic layer, the nonmagnetic intermediate layer and the second pinned magnetic layer extends to the rear of the nonmagnetic layer and the free magnetic layer in the height direction; and

the antiferromagnetic layer is formed in contact with the upper surface of the rear portion of the second pinned magnetic layer which extends in the height direction.

7. (Original) The CPP giant magnetoresistive head according to claim 6, further comprising nonmagnetic metal films interposed between the lower shield layer and the first pinned magnetic layer and between the free magnetic layer and the upper shield layer.

8. (Original) The CPP giant magnetoresistive head according to claim 7, wherein each of the nonmagnetic metal films comprises a nonmagnetic metallic material containing at least one element selected from Au, Ag, Cu, Ru, Rh, Ir, Pd, Ni-Cr, (Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

9. (Original) The CPP giant magnetoresistive head according to claim 7, wherein the nonmagnetic metal film interposed between the lower shield layer and the first pinned magnetic layer comprises any one of Ta/Cu, Ta/Ru/Cu, Ta/Cr, Ta/Ni-Cr, Ta/(Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

10. (Original) The CPP giant magnetoresistive head according to claim 6, wherein part or entirety of the second pinned magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

11. (Original) The CPP giant magnetoresistive head according to claim 6, wherein part or entirety of the free magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

12. (Original) The CPP giant magnetoresistive head according to claim 6, further comprising an insulating layer interposed between the antiferromagnetic layer and the upper shield layer.

13. (Original) The CPP giant magnetoresistive head according to claim 1, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

14. (Original) The CPP giant magnetoresistive head according to claim 6, wherein the antiferromagnetic layer comprises an antiferromagnetic metal layer in contact with the upper surface of the second pinned magnetic layer and an insulating antiferromagnetic layer laminated on the antiferromagnetic metal layer.

15. (Original) The CPP giant magnetoresistive head according to claim 13, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

16. (Original) The CPP giant magnetoresistive head according to claim 14, wherein the antiferromagnetic metal layer comprises Pt-Mn or Ir-Mn.

17. (Withdrawn) The CPP giant magnetoresistive head according to claim 3; wherein the pinned magnetic layer has the ferrimagnetic structure comprising the first pinned magnetic layer and the second pinned magnetic layer which are laminated with the nonmagnetic intermediate layer provided therebetween;

the nonmagnetic layer and the free magnetic layer are formed on the second pinned magnetic layer;

each of the first pinned magnetic layer, the nonmagnetic intermediate layer and the second pinned magnetic layer extends to the rear of the nonmagnetic layer and the free magnetic layer in the height direction; and

the antiferromagnetic layer is in contact with the lower surface of the rear portion of the first pinned magnetic layer which extends in the height direction.

18. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, further comprising a nonmagnetic metal film provided on the lower shield layer,

the antiferromagnetic layer is formed on the rear end portion of the nonmagnetic metal film in the height direction, and the first pinned magnetic layer is formed over the antiferromagnetic layer and the nonmagnetic metal film.

19. (Withdrawn) The CPP giant magnetoresistive head according to claim 18, wherein the nonmagnetic metal film provided on the lower shield layer comprises any one of Ta/Cu, Ta/Ru/Cu, Ta/Cr, Ta/Ni-Cr, Ta/(Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

20. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, further comprising a nonmagnetic metal film comprising a nonmagnetic metallic material and interposed between the upper shield layer and the free magnetic layer; wherein the nonmagnetic metallic material contains at least one element of Au, Ag, Cu, Ru, Rh, Ir, Pd, Ni-Cr, (Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

21. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, wherein part or entirety of the second pinned magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

22. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, wherein part or entirety of the free magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

23. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, further comprising an insulating layer interposed between the upper shield layer and the rear portion of the second pinned magnetic layer which extends in the height direction.

24. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

25. (Withdrawn) The CPP giant magnetoresistive head according to claim 24, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

26. (Withdrawn) The CPP giant magnetoresistive head according to claim 17, further comprising a magnetostrictive enhancement layer provided immediately below the first pinned magnetic layer and interposed between the first pinned magnetic layer and the antiferromagnetic layer in a rear region in the height direction, the magnetostrictive enhancement layer being thinner than the antiferromagnetic layer, having the same composition as the antiferromagnetic layer and a disordered crystal structure, and producing mismatch strain at the interface with the first pinned magnetic layer.

27. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, wherein each of the antiferromagnetic layer and the magnetostrictive enhancement layer comprises a Z-Mn alloy (wherein Z is at least one element of Pt, Pd, Ir, Rh, Ru, Os, Ni, and Fe).

28. (Withdrawn) The CPP giant magnetoresistive head according to claim 27, wherein the crystal of the first pinned magnetic layer is epitaxial or heteroepitaxial

to the crystal of the magnetostrictive enhancement layer.

29. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the magnetostrictive enhancement layer has a face-centered cubic structure near the interface with the first pinned magnetic layer, and an equivalent crystal plane represented by {111} plane is preferentially oriented in parallel with the interface.

30. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the thickness of the magnetostrictive enhancement layer is 5 Å to 50 Å.

31. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the Z element content of the Z-Mn alloy used for forming the antiferromagnetic layer and the magnetostrictive enhancement layer is 40 atomic percent to 95 atomic percent.

32. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the first pinned magnetic layer has a face-centered cubic structure near the interface with the magnetostrictive enhancement layer, and an equivalent crystal plane represented by {111} plane is preferentially oriented in parallel with the interface.

33. (Withdrawn) The CPP giant magnetoresistive head according to claim 32, wherein the first pinned magnetic layer comprises Co or Co_nFe_m ($m \leq 20$ and $n + m = 100$).

34. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the first pinned magnetic layer has a body-centered cubic structure (bcc)

near at least the interface with the magnetostrictive enhancement layer, and an equivalent crystal plane represented by {110} plane is preferentially oriented in parallel with the interface.

35. (Withdrawn) The CPP giant magnetoresistive head according to claim 34, wherein the first pinned magnetic layer comprises Co_nFe_m ($m \geq 20$ and $n + m = 100$)

36. (Withdrawn) The CPP giant magnetoresistive head according to claim 28, wherein the first pinned magnetic layer has a face-centered cubic structure near the interface with the magnetostrictive enhancement layer, an equivalent crystal plane represented by {111} plane being preferentially oriented in parallel with the interface, and the first pinned magnetic layer has a body-centered cubic structure near the interface with the nonmagnetic intermediate layer, an equivalent crystal plane represented by {110} plane being preferentially oriented in parallel with the interface.

37. (Withdrawn) The CPP giant magnetoresistive head according to claim 36, wherein the first pinned magnetic layer has a composition of Co or Co_nFe_m ($m \leq 20$ and $n + m = 100$) near the interface with the magnetostrictive enhancement layer, and a composition of Co_nFe_m ($m \geq 20$ and $n + m = 100$) near the interface with the nonmagnetic intermediate layer.

38. (Withdrawn) The CPP giant magnetoresistive head according to claim 37, wherein the first pinned magnetic layer has a Fe concentration gradually increasing from the interface with the magnetostrictive enhancement layer to the interface with the nonmagnetic intermediate layer.

39. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, wherein nonmagnetic metal films are interposed between the lower shield layer and the magnetostrictive enhancement layer and the antiferromagnetic layer and between the free magnetic layer and the upper shield layer.

40. (Withdrawn) The CPP giant magnetoresistive head according to claim 39, wherein the nonmagnetic metal film comprises a nonmagnetic metallic material containing at least one element of Au, Ag, Cu, Ru, Rh, Ir, Pd, Ni-Cr, (Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

41. (Withdrawn) The CPP giant magnetoresistive head according to claim 40, wherein the nonmagnetic metal film interposed between the lower shield layer and the magnetostrictive enhancement layer and the antiferromagnetic layer comprises any one of Ta/Cu, Ta/Ru/Cu, Ta/Cr, Ta/Ni-Cr, Ta/(Ni-Fe)-Cr, and Cr, and when the material contains Cr, the Cr content exceeds 20 atomic percent.

42. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, further comprising an insulating layer interposed between the upper shield layer and a rear portion of the second pinned magnetic layer extending in the height direction.

43. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, wherein part or entirety of the second pinned magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

44. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, wherein part or entirety of the free magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

45. (Withdrawn) The CPP giant magnetoresistive head according to claim 26, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

46. (Withdrawn) The CPP giant magnetoresistive head according to claim 45, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

47. (Original) The CPP giant magnetoresistive head according to claim 3; wherein the pinned magnetic layer has a laminated ferrimagnetic structure comprising a first pinned magnetic layer and a second pinned magnetic layer which are laminated with a nonmagnetic intermediate layer provided therebetween;

the nonmagnetic layer and the free magnetic layer are provided below the second pinned magnetic layer;

the first pinned magnetic layer extends to the rear of the free magnetic layer, the nonmagnetic layer, the second pinned magnetic layer and the nonmagnetic intermediate layer in the height direction; and

the antiferromagnetic layer is in contact with the upper surface of the rear portion of the first pinned magnetic layer extending in the height direction.

48. (Original) The CPP giant magnetoresistive head according to claim 47, further comprising nonmagnetic metal films interposed between the lower shield layer and the free magnetic layer and between the first pinned magnetic layer and the upper shield layer.

49. (Original) The CPP giant magnetoresistive head according to claim 48, wherein the nonmagnetic metal film comprises a nonmagnetic metallic material containing at least one element of Au, Ag, Cu, Ru, Rh, Ir, Pd, Ni-Cr, (Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

50. (Original) The CPP giant magnetoresistive head according to claim 48, wherein the nonmagnetic metal film interposed between the first pinned magnetic layer and the upper shield layer comprises a first upper nonmagnetic metal film disposed to cover the upper surface of the antiferromagnetic layer, and a second upper nonmagnetic metal film disposed over the first upper nonmagnetic metal film and the first pinned magnetic layer, the first upper nonmagnetic metal film comprising Cr.

51. (Original) The CPP giant magnetoresistive head according to claim 48, wherein the nonmagnetic metal film interposed between the lower shield layer and the free magnetic layer comprises any one of Ta/Cu, Ta/Ru/Cu, Ta/Cr, Ta/Ni-Cr, Ta/(Ni-Fe)-Cr, and Cr, and when the material contains Cr, the Cr content exceeds 20 atomic percent.

52. (Original) The CPP giant magnetoresistive head according to claim 47, wherein part or entirety of the second pinned magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

53. (Original) The CPP giant magnetoresistive head according to claim 47,

wherein part or entirety of the free magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

54. (Original) The CPP giant magnetoresistive head according to claim 47, further comprising an insulating layer provided below the first pinned magnetic layer and disposed in the rear of the free magnetic layer, the nonmagnetic layer, the second pinned magnetic layer and the nonmagnetic intermediate layer in the height direction.

55. (Original) The CPP giant magnetoresistive head according to claim 47, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

56. (Original) The CPP giant magnetoresistive head according to claim 47, wherein the antiferromagnetic layer comprises an antiferromagnetic metal layer in contact with the first pinned magnetic layer and an insulating antiferromagnetic layer laminated on the antiferromagnetic metal layer.

57. (Original) The CPP giant magnetoresistive head according to claim 55, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

58. (Original) The CPP giant magnetoresistive head according to claim 56, wherein the antiferromagnetic metal layer comprises Pt-Mn or Ir-Mn.

59. (Original) The CPP giant magnetoresistive head according to claim 3; wherein the pinned magnetic layer has a laminated ferrimagnetic structure comprising a first pinned magnetic layer and a second pinned magnetic layer which

are laminated with a nonmagnetic intermediate layer provided therebetween;

the nonmagnetic layer and the free magnetic layer are formed below the second pinned magnetic layer;

each of the second pinned magnetic layer, the nonmagnetic intermediate layer and the first pinned magnetic layer extends to the rear of the nonmagnetic layer and the free magnetic layer in the height direction; and

the antiferromagnetic layer is formed in contact with the upper surface of the rear portion of the first pinned magnetic layer which extends in the height direction.

60. (Original) The CPP giant magnetoresistive head according to claim 59, further comprising an antioxidative layer comprising an inoxidizable nonmagnetic material and provided between the nonmagnetic layer and the second pinned magnetic layer.

61. (Original) The CPP giant magnetoresistive head according to claim 60, wherein the antioxidative layer is formed to a thickness of 5 Å to 10 Å.

62. (Original) The CPP giant magnetoresistive head according to claim 59, further comprising nonmagnetic metal films provided between the lower shield layer and the free magnetic layer and between the first pinned magnetic layer and the upper shield layer.

63. (Original) The CPP giant magnetoresistive head according to claim 62, wherein each of the nonmagnetic metal film comprises a nonmagnetic metallic material containing at least one element of Au, Ag, Cu, Ru, Rh, Ir, Pd, Ni-Cr, (Ni-Fe)-Cr, and Cr, and when the nonmagnetic metallic material contains Cr, the Cr content exceeds 20 atomic percent.

64. (Original) The CPP giant magnetoresistive head according to claim 62, wherein the nonmagnetic metal film interposed between the first pinned magnetic layer and the upper shield layer comprises a first upper nonmagnetic metal film disposed to cover the upper surface of the antiferromagnetic layer, and a second upper nonmagnetic metal film disposed over the first upper nonmagnetic metal film and the first pinned magnetic layer, and the first upper nonmagnetic metal film comprises Cr.

65. (Original) The CPP giant magnetoresistive head according to claim 62, wherein the nonmagnetic metal film interposed between the lower shield layer and the free magnetic layer comprises any one of Ta/Cu, Ta/Ru/Cu, Ta/Cr, Ta/Ni-Cr, Ta/(Ni-Fe)-Cr, and Cr, and when the material contains Cr, the Cr content exceeds 20 atomic percent.

66. (Original) The CPP giant magnetoresistive head according to claim 59, wherein part or entirety of the second pinned magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

67. (Original) The CPP giant magnetoresistive head according to claim 59, wherein part or entirety of the free magnetic layer comprises Fe-Co-Cu (wherein Fe > 10 atomic percent, Co > 30 atomic percent, and Cu > 5 atomic percent), Fe-Co-Cu-X (wherein X is at least one element of Pt, Pd, Mn, Si, Au, and Ag), or Co₂MnY (wherein Y is at least one element of Ge, Si, Sn, and Al).

68. (Original) The CPP giant magnetoresistive head according to claim 59, further comprising an insulating layer interposed below the second pinned magnetic

layer and disposed in the rear of the free magnetic layer and the nonmagnetic layer in the height direction.

69. (Original) The CPP giant magnetoresistive head according to claim 59, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

70. (Original) The CPP giant magnetoresistive head according to claim 59, wherein the antiferromagnetic layer comprises an antiferromagnetic metal layer in contact with the first pinned magnetic layer and an insulating antiferromagnetic layer laminated on the antiferromagnetic metal layer.

71. (Original) The CPP giant magnetoresistive head according to claim 69, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

72. (Original) The CPP giant magnetoresistive head according to claim 70, wherein the antiferromagnetic metal layer comprises Pt-Mn or Ir-Mn.

73. (Withdrawn) The CPP giant magnetoresistive head according to claim 3; wherein the pinned magnetic layer has a laminated ferrimagnetic structure comprising a first pinned magnetic layer and a second pinned magnetic layer which are laminated with a nonmagnetic intermediate layer provided therebetween;

the nonmagnetic layer and the free magnetic layer are formed below the second pinned magnetic layer;

each of the first pinned magnetic layer, the nonmagnetic intermediate layer and the second pinned magnetic layer extends to the rear of the nonmagnetic layer and the free magnetic layer in the height direction; and

the antiferromagnetic layer is an insulating antiferromagnetic layer formed in contact with the lower surface of the rear portion of the second pinned magnetic

layer which extends in the height direction.

74. (Withdrawn) The CPP giant magnetoresistive head according to claim 73, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

75. (Withdrawn) A CPP giant magnetoresistive head comprising:
lower and upper shield layers with a predetermined shield distance therebetween; and

a dual spin-valve giant magnetoresistive element comprising a lower pinned magnetic layer, a lower nonmagnetic layer, a free magnetic layer, an upper nonmagnetic layer, and an upper pinned magnetic layer, which are disposed in turn between the upper and lower shield layers, a current flowing perpendicularly to the film plane of the giant magnetoresistive element,

wherein an antiferromagnetic layer is provided in the rear of the giant magnetoresistive element in a height direction, for pinning the magnetization directions of the lower pinned magnetic layer and the upper pinned magnetic layer in the height direction.

76. (Withdrawn) The CPP giant magnetoresistive head according to claim 75; wherein

the lower pinned magnetic layer and the upper pinned magnetic layer extend to the rear of the free magnetic layer, the lower nonmagnetic layer and the upper nonmagnetic layer in the height direction; and

the antiferromagnetic layer produces an exchange coupling magnetic field at each of the interfaces with the upper surface of the lower pinned magnetic layer and the lower surface of the upper pinned magnetic layer, the lower and upper pinned magnetic layers extending in the height direction, so that the magnetization directions of the first and second pinned magnetic layers are pinned by the

respective exchange coupling magnetic fields.

77. (Withdrawn) The CPP giant magnetoresistive head according to claim 75, wherein the antiferromagnetic layer is an insulating antiferromagnetic layer.

78. (Withdrawn) The CPP giant magnetoresistive head according to claim 75, wherein the antiferromagnetic layer comprises an antiferromagnetic metal layer in contact with the lower pinned magnetic layer and an insulating antiferromagnetic layer in contact with the upper pinned magnetic layer.

79. (Withdrawn) The CPP giant magnetoresistive head according to claim 77, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.

80. (Withdrawn) The CPP giant magnetoresistive head according to claim 78, wherein the antiferromagnetic metal layer comprises Pt-Mn or Ir-Mn.

81. (Withdrawn) The CPP giant magnetoresistive head according to claim 75, wherein the lower pinned magnetic layer and the upper pinned magnetic layer extend to the rear of the free magnetic layer, the lower nonmagnetic layer and the upper nonmagnetic layer in the height direction, and the antiferromagnetic layer comprises a first antiferromagnetic layer for pinning the magnetization direction of the lower pinned magnetic layer in the height direction by an exchange coupling magnetic field produced at the interface with the upper surface of the lower pinned magnetic layer, and a second antiferromagnetic layer for pinning the magnetization direction of the upper pinned magnetic layer in the height direction by an exchange coupling magnetic field produced at the interface with the lower surface of the upper pinned magnetic layer.

82. (Withdrawn) The CPP giant magnetoresistive head according to claim 81, wherein the second antiferromagnetic layer is an insulating antiferromagnetic layer.

83. (Withdrawn) The CPP giant magnetoresistive head according to claim 82, wherein the insulating antiferromagnetic layer comprises Ni-O or α -Fe₂O₃.